Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 345

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER February 5, 1916

NOTES ON THE PREOVIPOSITION PERIOD OF THE HOUSE FLY, MUSCA DOMESTICA L.

By R. H. HUTCHISON, *Scientific Assistant.*

CONTENTS.

	Page.		Page.
Introduction	1	Longevity	12
The preoviposition period	3	Summary	13
Copulation	12	Literature cited	13

INTRODUCTION.

During recent years a great deal of emphasis has been laid upon the use of flytraps as a means of reducing and controlling flies. The popularity of trapping is based not only on the immediate results obtained, but also upon the claim that many female flies will be caught before they have laid their first eggs, and that thus the possible number of future generations will be greatly reduced. For much the same reason it has been urged that trapping flies in the early spring is effective in reducing the number of future generations. An apparent justification for this method of control was found in the published records of experiments and observations indicating a rather long period of time between the emergence of the adult fly and the first deposition of eggs.

Entomologists have been aware that these methods of control were founded upon a rather meager scientific basis. Comparatively few accurate data have been published bearing upon the length of the preoviposition period. The necessity of more data on this phase of the life history of the house fly was clearly pointed out by Dr. L. O. Howard (1911), and upon his suggestion work along these lines was begun during the season of 1913. The work has been carried out under the general direction of Mr. W. D. Hunter. A few experiments on the preoviposition period were carried out by the writer during the season of 1913 at Arlington, Va., and others during the spring of

NOTE.—This paper is intended for entomologists and others who are interested in the extermination of house flies.

1914 at New Orleans, La., at which place Mr. T. E. Holloway rendered great assistance. During the summer of 1914 an extended series of experiments was carried out by Mr. A. W. J. Pomeroy. After the severance of his connection with the bureau at the end of October the experiments which he had under way were continued during the fall by Mr. J. L. Webb, and during the winter months the writer continued the work in the greenhouses of the Arlington experiment farm of the Bureau of Plant Industry.

METHODS USED IN THE PREOVIPOSITION EXPERIMENTS.

In the experiments to determine the length of the preoviposition period (i. e., the time between the emergence of the adult fly and the first deposition of eggs) laboratory-bred flies were used. The breeding was carried out in a systematic way, and several strains or "pure lines" were followed out through five or six generations. Most of the strains were started from a small number of larvæ or pupæ found in manure piles, and the first flies to emerge from material thus collected were used as the parents of the strain. In one case, however, a strain was started from a pair of flies taken in coitu on July 25, 1914. Eggs were deposited on August 2, and breeding of this strain was continued through six generations.

The adult flies were kept in small cages. A type of cage found very satisfactory for this work was 22 inches high by 12 inches square. The framework was of soft pine 1 inch square. The top, bottom, and three sides were covered with bronzed screen wire, 16 mesh per inch. The fourth side, or front of the cage, was covered with screen wire about 8 inches down from the top. Below this was a board about 8 inches wide, in which was cut an armhole 5 inches in diameter. A sleeve of closely-woven black cloth was tacked over this. Below the board was fitted a drawer 4 inches deep, in which food and material for deposition were kept. Cages of this size were easily and quickly handled, and any part of the interior of the cage could be easily reached through the armhole, the sleeve preventing the escape of any flies during manipulations. The sliding drawer at the bottom of the cage made it possible to remove the contents and examine them for eggs without permitting any flies to escape. These cages were kept on the shelves of a screened insectary and were protected from the direct rays of the sun most of the day, but were freely exposed to air currents and to the outdoor conditions of temperature and humidity.

Flies were transferred to these cages soon after emergence and supplied with food and media for oviposition. The cages were examined daily; any dead flies were removed and the sex noted at the time of removal. In this way at the end of the experiment the total number of males and females was summed up, and the length of life of each fly in the lot was known. The manure or other medium

was removed each day and examined carefully for eggs. Fresh horse manure was supplied each day, care being taken that the manure was not fly-blown before it was introduced into the cages. This was managed by taking fresh manure from the stables early in the morning and keeping it in covered cans until used, and then examining it before introducing it into the cages. During midsummer the additional precaution was taken of boiling the manure for one-half hour before it was put in the cages. When other media were used for oviposition the same precautions against previous infestation were taken. At the time of the daily examination of the cages, and at other times as opportunity offered, observations were made as to copulations. As a rule a regular routine of observations was followed out with each lot of flies as long as any of them remained alive. In a few cases, however, the flies were killed after the first deposition of eggs in order to provide cage space for the new lots of flies emerging.

When, upon examination of the cages, it was found that eggs had been deposited, these were transferred, together with the medium, to small breeding boxes. These breeding boxes were of wood and very tightly made so that no cracks offered a chance for the escape of migrating larvæ. Boxes of two sizes were used. When the number of eggs was small they were bred out in small boxes measuring 8 by 8 by 10 inches, and for larger lots boxes measuring 12 by 18 by 12 inches were used. In one end of these boxes was an armhole 5 or 6 inches in diameter. Tacked carefully over this was a sleeve of black cloth of close weave. This was kept tightly closed with a rubber band when not in use. The top of each box was covered with a glass plate. Thus any flies could be seen as soon as they emerged.

As soon after emergence as possible the flies were transferred from the breeding boxes to the cages described above. This was done by capturing them in vials introduced through the sleeve, or by connecting the armhole of the breeding box with that of the cage by means of a glass cylinder. When the breeding box was darkened the flies soon found their way into the cage through the cylinder. Sometimes the puparia were collected from a breeding box before any emergence had taken place and put into vials or pill boxes and covered with sand. These were put into cages until emergence had occurred. After the first lot of flies had emerged the remaining puparia were transferred to another cage to obtain a second lot, and so on until all had emerged.

THE PREOVIPOSITION PERIOD.

The preoviposition period was determined in some 70 experiments during the season of 1914. Table I summarizes the results of these experiments, most of which are based on Mr. Pomeroy's notes but which include also some experiments by Mr. Webb and the writer, carried out during the autumn and winter. They have been arranged in the table in the order of the increasing length of the period.

TABLE I.—*Preoviposition period of the house fly, Musca domestica.*

Lot number.	Food of larvæ.	Food of adults.	Number of adults in lot.		Date of emergence.	Preoviposition period.	Average mean temperature.	Longevity.		Remarks.
			Male.	Female.				Minimum.	Maximum.	
						Days.[1]	°*F.*	*Days.*	*Days.*	
1	Moist bran	Banana, water, manure	(?)	(?)	Aug. 18, 10.30 a. m., to Aug. 19, 9.30 a. m.	2½	82.5			
2	do	Banana, corn syrup, rotten potato.	(?)	(?)	Aug. 17, 3.30 p. m., to Aug. 18, 10.30 a. m.	3	82			All killed Aug. 24.
3	do	Banana, water, manure	(?)	(?)	Aug. 19, 9.30 a. m. to 4.15 p. m.	3	80.6			
4	Manure[2]	Banana, water, manure and bran.	4	3	July 14	3	79.2			
5	Moist bran	Corn syrup, water, manure	(?)	(?)	Aug. 17	4	82	7	22	
6	Manure one-half, bran one-half.	Corn syrup, water, rotten potato.	(?)	(?)	Aug. 19	4	79.4	6	(?)	
7	do	Brown sugar, water, manure.	11	5	Aug. 28	4	74.5	1	54	
8	Manure in compost heap.	Banana, water, manure	15	7	July 21, 12 m., to July 22, 2 p. m.	4	82.1	3	43	
9	Manure one-half, bran one-half.	White sugar, water, manure.	(?)	(?)	Aug. 29, 12 m., to Aug. 30, 11 a. m.	5	74.3	5	51	
10	Bread moistened with milk.	Banana, water, manure and bran.	(?)	(?)	July 20 to July 21, 1 p. m	5	81.6	6	38	
11	Manure in compost heap.	Banana, water, manure	3	6	July 21	5	81.6	3	(?)	2 males escaped.
12	(?)	Brown sugar, water, manure.	(?)	(?)	Aug. 31, 12 m., to Sept. 1, 12 m.	6	72	3	42	
13	Manure in compost heap.	Banana, beer, manure	(?)	(?)	June 22, 4 p. m., to June 23, 10 a. m.	6(?)	79.9	10	29(?)	
14	Manure	Banana, water, manure, rotten potato	(?)	(?)	Aug. 11	6	74.5			
15	Manure one-half, bran one-half.	Brown sugar, water, manure.	(?)	(?)	Aug. 29	6	74	2	52	
16	Manure one-half, crushed oats one-half.	do	14	4	Oct. 24 to Oct. 26	6		5	26	In greenhouse. Fungus killed most of these flies.
17	Manure one-half, bran one-half.	Corn syrup, water, manure	(?)	(?)	Aug. 17, 12 m. to 3.30 p. m.	6	79.7	8	19+	
18	Manure	Banana, water, manure	(?)	(?)	Sept. 2	6	69.2	10	22+	
19	Manure in compost heap.	Bread, beer, manure	[3] 102		June 22, 4 p. m., to June 23, 10 a. m.	7	78.5	2	29	
20	Pig manure, bran mixture.	Banana, water, manure	63	41	July 24, 2.30 p. m., to July 25, 11.30 a. m.	8	72			All flies killed on Aug. 3.
21	Manure	Milk, bread, manure	[3] 40		June 22, 4 p. m., to June 23, 10 a. m.	8	78.4	3	25	

22	Manure one-half, bran one-half.	Corn syrup, water, manure.	205	191	Aug. 15, 12 m., to Aug. 17, 11.30 a. m.	9	78.5	8	27	
23	Manure one-half, crushed oats one-half.	Brown sugar, water, manure.	6	5	Oct. 1, 11 a. m., to Oct. 3, 4.15 p. m.	9	64	7	22	Experiment ended by fungus.
24	(?)	Banana, water, manure	(?)	(?)	Sept. 1, 2 p. m., to Sept. 2, 10 a. m.	9	67.7	3	(?)	
25	(?)	Grape juice, manure	8	5	Sept. 2, 10 a. m., to Sept. 3, 4 p. m.	9	65	3	(?)	
26	Manure	Sugar, water, manure	26	8(?)	July 23, 3.15 p. m., to July 24, 11 a. m.	10	73.2	1	24	
27	do	Brown sugar, water, fresh manure.	22	10	Oct. 1, 4 p. m., to Oct. 3, 11 a. m.	10	65.6	14	18	Fungus first developed on fourth day after emergence.
28	do	Bread, beer, water, manure.	[3] 93		June 23, 3 p. m., to June 24, 3 p. m.	10	68.3	4	(?)27	
29	Pig manure, bran mixture.	Banana, water, manure	24	22	Dec. 1, 12 m., to Dec. 2, 12 m.	10	61.3	5	12	These flies bred from puparia collected at Bethesda, Md., Nov. 13, 1914. Bred in insectary, adults kept in greenhouse.
30	Manure one-half, crushed oats one-half.	do	15	18	Nov. 7, 12 m., to Nov. 10, 12 m.	10		10	16	In greenhouse. Fungus killed all these flies.
31	Manure	Banana, water, fresh manure.	(?)	(?)	Sept. 7	11	60.1			
32	do	Brown sugar, water, manure.	12	13	Oct. 6, 9 a. m., to Oct. 9, 4 p. m.	11	64.3	4	41	No food for adults from Oct. 6 to 9.
33	Manure in compost heap.	Banana, manure	[3] 42		June 21, 4 p. m., to June 22, 4 p. m.	11	76.6	2	26	
34	Manure	Brown sugar, water, fresh manure.	13	7	Oct. 6, 10 a. m., to Oct. 8, 11 a. m.	11	64.3	16	24	Fungus appeared on seventeenth day after emergence.
35	do	Brown sugar, water, manure.	110	73	Oct. 3, 2 p. m., to Oct. 5, 11 a. m.	11	64.7	5	40	
36	(?)	do	(?)	(?)	Oct. 2 to Oct. 3, 3.30 p. m.	11	65	13	26	
37	Manure	White sugar, beer, manure.	5	4	Sept. 3	12	62.2	19	32	
38	do	Grape juice, water, manure.	5	8	Sept. 3, 2 to 4.30 p. m.	12	62.2	7	19(?)	
39	Manure in compost heap.	Banana, water, manure	[3] 43		June 21, 4 p. m., to June 22, 4 p. m.	12	76	14	29	
40	do	do	12	7	do	12	76	7	24	
41	Manure	do	(?)	(?)	Sept. 2	12	62.6	2	21	2 males remaining on Sept. 24 were killed and experiment ended.
42	(?)	White sugar, water, manure.	(?)	(?)	Aug. 30, 12 m., to Aug. 31, 12 m.	12	66.6	(?)	35	
43	Fresh manure	Banana, water, manure	[3] 33		Jan. 27, 12 m., to Jan. 28, 1 p. m.	12	67.8	4	30+	In greenhouse.
44	do	Banana with manure	17	12	Feb. 6, 3 p. m., to Feb. 8, 11 a. m.	12	71.7	5	22	Do.
45	Manure one-half, crushed oats one-half.	Brown sugar, water, manure.	8	3	Sept. 29, 3 p. m., to Oct. 1, 11 a. m.	13	63.7	13	35+	Last fly (female) escaped Nov. 4.

[1] Approximate.

[2] The term "manure" means "horse manure" unless otherwise stated.

[3] Sex not determined.

TABLE I.—*Preoviposition period of the house fly, Musca domestica*—Continued.

Lot number.	Food of larvæ.	Food of adults.	Number of adults in lot.		Date of emergence.	Preoviposition period.	Average mean temperature.	Longevity.		Remarks.
			Male.	Female.				Minimum.	Maximum.	
						Days.[1]	°*F.*	*Days.*	*Days.*	
46	Manure one-half, bran one-half.	Corn sirup, water, bread, manure.	9	21	July 24, 1 p. m., to July 25, 11 a. m.	14	80	9	38	
47	Manure	Brown sugar, water, manure.	52	17	Sept. 22	14	61.2	6	35	
48	Manure one-half, crushed oats one-half.	do	16	7	Sept. 27, a. m., to Oct. 1, 2 p. m.	14	62	10	31	
49	Manure	Banana, water, manure	20	15	Sept. 25, 3 p. m., to Sept. 26, 3 p. m.	14	61.5	14	31	
50	Manure one-fourth, crushed oats three-fourths.	Brown sugar, water, manure.	97	59	Sept. 25	14	60.6	3	32	
51	Manure	Banana, water, manure	(?)	(?)	Sept. 7, 2 p. m., to Sept. 9, 12.30 p. m.	14	62.6	4	45	
52	Manure, previously boiled.	do	(?)	(?)	Sept. 8	14	62.5	4	36	
53	Manure	Brown sugar, manure, rotten potato.	8	8	Sept. 2, 4.30 p. m., to Sept. 3, 4 p. m.	14	62.5	1	46	
54	do	Brown sugar, water, manure.	(?)		Oct. 5, 9 a. m., to Oct. 6, 12 m.	14	62.3	8	31+	Mice destroyed flies or permitted them to escape on thirty-first day.
55	Manure one-fourth, crushed oats three-fourths.	do	17	20	Sept. 26 to Oct. 1, 3 p. m.	15	66.7	9	24	No food for adults before Oct. 1, 3 p. m.
56	Manure one-half, crushed oats one-half.	do	80+	91+	Sept. 25, 2.30 p. m., to Sept. 26, 3 p. m.	16	62.5	2	51	
57	Bran-pig manure mixture.	Corn sirup, bread, manure	18	13	July 24, 1 p. m., to July 25, 11 a. m.	16	75.2	10	40 (?)	
58	Manure	Brown sugar, water, manure.	? 6	? 2	Oct. 15 to Oct. 21, 1. p. m.	16	.....	9	32	Cage started Oct. 21. Kept in greenhouse.
59	do	Grape juice, fresh manure	(?)	(?)	Sept. 2, 4.30 p. m., to Sept. 3, 3.30 p. m.	17	63	2	21	
60	do	Banana, water, manure	21	10	Sept. 5, 12 m., to Sept. 7, 2 p. m.	17	64.1	8	43	
61	do	Brown sugar, water, manure.	94+	34+	Sept. 22, 3 p. m., to Sept. 23, 4 p. m.	17	61.6	5	31+	Last male killed Oct. 24.
62	Manure one-fourth, crushed oats three-fourths.	White sugar, water, manure	21	13	Sept. 24	17	61.5	1	36	

63	.....	Brown sugar, water, manure.	(?)	(?)	Aug. 6 to Aug. 7, 11 a. m.....	17	78.7	1	(?)		
64	Manure.....	Banana, water, manure.....	(?)	(?)	Sept. 25, 8 a. m., to Sept. 26, 2 p. m.	18	59.1	13	29	Fungus killed numbers in latter part of experiment.	
65	.....do.....	Brown sugar, water, manure.	6	8	Oct. 4.....	19	63	19	30	Oct. 23 was latest date on which eggs were obtained in these experiments under outd oor conditions.	
66	Manure one-half, crushed oats one-half.	.....do.....	67	50	Sept. 24.....	19	61.7	4	40		
67	Manure.....	.....do.....	.....	.....	Sept. 22.....	20	63.5	3	42		
68	.....do.....	White sugar, water, manure.	16	9	Sept. 24.....	22	61	4	40		
69	.....do.....	White sugar, vanilla extract, manure.	7	6	Sept. 2.....	23	65.1	6	41		

[1] Approximate.

TABLE II.—*Preoviposition period of the house fly; tests with isolated pairs.*

No.	Food of larvæ.	Food of adults.	Date of emergence.	Taken in coitu.	Emergence to copulation.	Copulation to oviposition.	Total preoviposition period.	Average mean temperature.	Number of depositions.	Number of eggs per deposition.		Longevity of—		Remarks.
										First.	Second.	Male.	Female.	
					Days.	*Days.*	*Days.*	° *F.*				*Days.*	*Days.*	
1	Manure.....	Corn sirup, water, manure.	Aug. 11...	Aug. 14, 2.30 p. m..	3	6	9	71.2	2	30	40	(1)	(1)	
2	.....do.....	Banana, water, manure.	...do	.....do.....	3	6	9	71.2	1	96	.....	6	13	
3	.....do.....	.....do.....	...do.....	Aug. 14, 11.30 a. m.	3	6	9	71.2	1	25	.....	18	21	
4	.....do.....	.....do.....	...do.....	.....do.....	3	6	9	71.2	2	33	77	14	15	
5	Pig manure, bran mixture.	.....do.....	July 24, 2.30 p. m., to July 25, 11.30 a.m.	July 31, 10.40 a. m.	6	3	9	73.7	1	87	.....	13	[2] (?)	No records of female after Aug. 7.
6	Manure.....	Sugar, bread, water, manure.	July 23, 3.15 p. m., to July 24, 11 a. m.	July 28, 2.30 p. m..	4	5	9	72.9	1	28	.....	10	[2] (?)	Do.
7	(?)	Banana, water, manure.	(?)	July 26, 2.30 p. m..	(?)	8	(?)	72	1	40	.....	[3] 4	[3] 14	

[1] At least 16.

[2] At least 13.

[3] Days after copulation.

Many attempts were made by Mr. Pomeroy to keep isolated pairs of flies under as natural conditions as possible in order to obtain not only the preoviposition period but also the number of depositions per fly and the number of eggs per deposition. The usual method was to remove from a lot of laboratory bred flies the first pair which were found in copulation. After transfer to a separate cage they were supplied with food and a medium for oviposition and were kept under observation in much the same way as the larger lots. The results of the tests with isolated pairs are summarized in Table II.

The fact that only 7 out of some 30 tests gave any positive results points to the difficulties in obtaining significant data from experiments performed under artificial conditions.

The shortest preoviposition period was about two and one-half days (Table I, lot No. 1). Mr. Pomeroy's original notes on this lot show that the "flies emerged some time between August 18, 10.30 a. m., and August 19, 9.30 a. m.," at which time they were "transferred to cage and supplied with banana, water, and fresh manure. Examined August 20 at 3.30 p. m. No eggs were found. Fresh manure supplied. August 21, at 1 p. m., two clusters of eggs were found, 80 to 90 eggs in each cluster." Now, if the flies which deposited these eggs had emerged on the afternoon of the 18th the preoviposition period was a little longer than two and one-half days. If they had emerged during the morning of the 19th before 9.30 a. m. the period was a little less than two and one-half days. Other remarkably short periods are to be found in the three 3-day periods shown in the table, and in the four 4-day records. It is reasonable to suppose that if these short periods were found under artificial experimental conditions they would be not at all uncommon under natural conditions.

The longest period was one of 23 days (Table I, lot No. 69). In general it may be said that the shortest records occurred in midsummer and that the longer ones were obtained during the autumn months. It is true that some long periods were found in summer, e. g., a 14-day and a 16-day record in July, but no short records were ever found during the autumn months. In other words, the length of the preoviposition period is greatly influenced by the temperature. A study of Table I will show that the arrangement according to the increasing length of the period corresponds in a rough way with the order of the decreasing mean temperatures of those periods. The relation between the temperature and the length of the preoviposition period is made clearer in the correlation table (Table III), in which the columns give the preoviposition period in days and the rows represent 2° intervals of temperature.

TABLE III.—*Correlation between the average mean temperature and the length of the preoviposition period of the house fly.*

Average mean temperatures in 2° intervals.	Length of the preoviposition period in days.																					
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
82° to 84°	1		1																			
80° to 82°		2	1	2									1									
78° to 80°		1	1		2	1	1	1								1						
76° to 78°										1												
74° to 76°			1	1							2				1							
72° to 74°					3		1	2	1													
70° to 72°								4			1											
68° to 70°					1				1													
66° to 68°								1			2			1								
64° to 66°								2	1	4						1						1
62° to 64°												1	4		1	1		1	1			
60° to 62°										1	3		4			2		1			1	
58° to 60°																	1					

To represent this relation graphically the average of the average mean temperatures for all the records of a given length has been taken, and the following figures obtained:

Length of period.	Number of records.	Average of the average mean temperatures.
Days.		° *F.*
2½	1	82.5
3	3	80.9
4	4	79.5
5	3	79.2
6	6	74.9
7	1	78.5
8	2	75.2
9	10	71.2
10	4	67.1
11	6	65.8
12	8	68.1
13	1	67.3
14	9	63.9
15	1	66.7
16	2	68.8
17	5	65.8
18	1	59.1
19	2	62.3
20	1	63.5
22	1	61
23	1	65.1

Figure 1 shows the curve obtained by plotting these figures. The broken line in the figure is the hyperbole which is the nearest approach to the actual experimental curve. If it is true that "the curve expressing the increase in rate of development is a true hyperbole" (Pearls, 1914), one must seek for an explanation of the many deviations from the true curve which are seen in the experimental curve. It is of course probable that if the accumulated effective temperature for each period were worked out, the resulting curve would show a much closer approach to a true hyperbole.

It is not necessary to point out that there were several other variables among the conditions of these experiments. For example, humidity is no doubt an important factor, but the lack of complete and accurate records of the relative humidity prevents making any statistical analysis of its influence on the length of the preoviposition period.

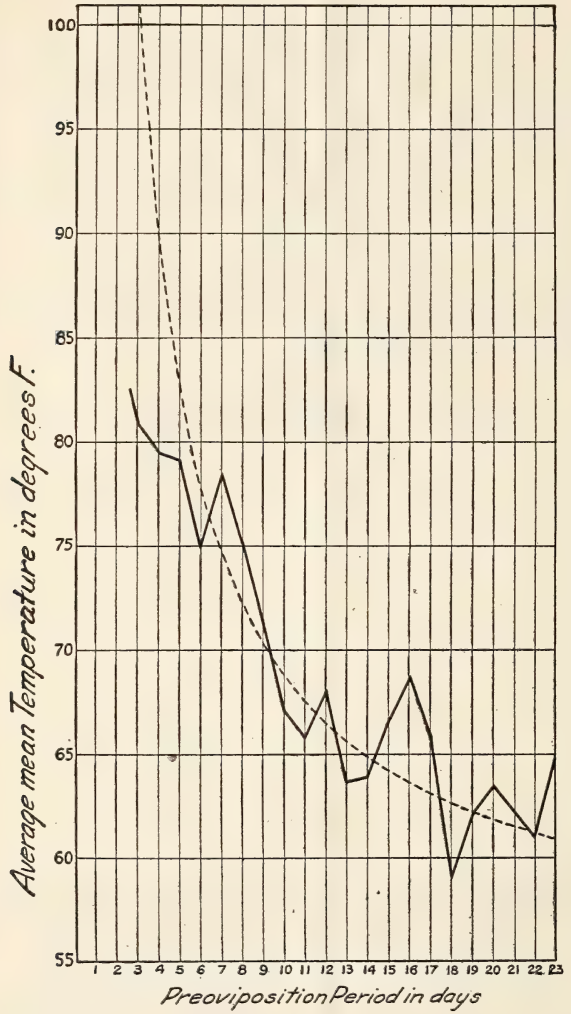

FIG. 1.—Curve showing correlation between the average mean temperature and the length of the preoviposition period of the house fly. (Original.)

It is interesting to note that Bishopp, Dove, and Parman (1915), in experiments at Dallas, Tex., obtained a 4-day record at an average mean temperature of 87.5° F., while the 4-day records at Arlington, Va., averaged 79.5° F. This and other differences between their results and those recorded in the present paper may in large part be due to the differences in the relative humidity of the two localities.

Bishopp, Dove, and Parman are doubtless correct in saying that in general "increased humidity seems to hasten egg laying."

The present results agree also with the Dallas observations in showing that the food supply of the adult flies has an important influence on the length of the preoviposition period. Banana, water, and manure was found to be a favorable combination in these experiments. Lack of moisture always proved fatal to flies, and without food they die within two or three days.

Yet temperature, humidity, and food supply are not the only factors which influence egg laying. If Table I be examined, such apparently contradictory results as an 8-day record at an average mean temperature of 72° F. (see No. 20) and a 12-day record at an average mean temperature of 76° F. (see No. 39) will be found. Mr. Pomeroy has suggested, and the writer is strongly of the opinion, that the kind and quality of the larval food is partly responsible for such apparent discrepancies. It is a well-known fact that the amount and kind of larval food have a marked influence on the size of the resulting adult flies, and there is no reason to doubt that the physiological activities of the adult are likewise affected. It appears in Table I that most of the shorter preoviposition records were obtained with flies which had been bred from larvæ fed on moist bran or a bran-manure mixture. From media which fermented less actively than these, or which were allowed to dry out, or were too small in quantity, the resulting flies were not only small but often failed to oviposit at all and usually lived a shorter time than large flies under the same conditions. Some larvæ bred exclusively on rotten potato produced a small race of flies which did not oviposit, due perhaps to the preponderance of starch in their diet. Griffith (1908) observes that small flies are incapable of reproduction.

In the experiments with isolated pairs of flies only 7 out of 30, or about 24 per cent, gave any positive results as regards the deposition of eggs. In the other experiments where a number of flies (8 to 200) were used in each lot, 70 out of 110, or about 63 per cent, gave positive results. It is possible that this may be accounted for by what may be called a psychological factor. The habit of the adult females of associating in large numbers in one favored spot in depositing eggs has been previously pointed out (Bishopp, Dove, and Parman, 1915), and it is probable that the isolation of a pair of flies is an abnormal condition which has its inhibiting effect.

As regards the number of depositions, the Arlington observations again agree with those made at Dallas in that it was impossible to obtain more than two lots of eggs from a single female, but this does not prove, of course, that under normal conditions the adult fly can not oviposit oftener. Griffith (1908) gives no details of experiments

or observations in support of his statement that the fly repeats the process of egg laying at intervals of 10 to 14 days till four batches have been laid. The largest number of eggs per deposition in these experiments was 96 and the smallest 25.

Recent experiments have placed the knowledge of the preoviposition period on a more complete basis and have shown that the period is considerably shorter than was previously thought to be the case. Dr. C. G. Hewitt publishes the results of experiments performed by him in England in 1907, in which the period was found to be 14 days. Griffith (1908) states that the adult fly can begin to lay eggs 10 days after emergence. Bogdanow (1903) publishes the results of some breeding experiments with the house fly. In a table given in his article it appears that in one experiment the first flies emerged on August 12 and the first eggs laid by these flies were found on August 18—a preoviposition period of 6 days.

COPULATION.

Observations on the copulation of flies were necessarily not continuous, but of chance observations there were a large number, and they show that copulation may occur as early as one day after emergence. There are three records of copulations taking place on the second day after emergence, and 14 records of copulations on the third day after emergence. The greatest number of records fall on the third to sixth days, inclusive. Copulations were observed as late as the twenty-sixth day, and in an experiment during the winter, when a lot of flies was kept in a stable where the air temperature ranged from 30° to 60° F., one copulation was observed on the forty-seventh day after emergence. The air temperature at the time was 55° F. During the autumn a number of copulations were observed taking place when the air temperature was 55° F., but no sexual activity was ever seen at temperatures lower than 55°.

LONGEVITY.

As stated, the daily routine of observations on the various lots of flies included the removal of dead flies and the recording of their sex and length of life. The experiments during the summer and fall of 1914 include records of some 3,000 flies. The longevity of these flies varied from 1 day to 54 days. The arithmetical mean of all these records was found to be 19+ days. This may perhaps be taken as the average for both sexes at all seasons. In midsummer the length of life is often much less and during the spring and autumn months is considerably more. In one hibernation experiment, in which flies were kept in a stable at temperatures varying from 30° to 60° F., a few lived as long as 70 days. This record was not included in calculating the mean longevity.

SUMMARY.

From the experiments reported in this paper it is seen that the shortest record for the preoviposition period was one of about 2½ days and the longest, one of 23 days, with most of the records falling on the fourth, fifth, sixth, ninth, twelfth, and fourteenth days after emergence.

It is shown that the temperature has a very decided influence on the length of the period.

Other factors influencing this period are humidity, the kind and quality of the food of the adults, and the kind and quality of the larval food with its resulting effect on the size and physiological condition of the adults. In the experiments with isolated pairs of flies very few results were obtained, which suggests that the association of a number of females in the process of egg laying is the normal habit and that isolation has an inhibiting effect.

Copulations were observed as early as the first day after emergence and as late as the forty-seventh day. No copulations have been noted when the air temperature has been below 55° F.

The maximum record for longevity was 70 days, and the minimum was one day or less. The average of the records of some 3,000 flies was slightly over 19 days.

LITERATURE CITED.

Bishopp, F. C., Dove, W. E., and Parman, D. C.
1915. Notes on certain points of economic importance in the biology of the house fly. *In* Jour. Econ. Ent., v. 8, No. 1, p. 54–71.

Bogdanow, E. A.
1903. Zehn Generationen der Fliegen (*Musca domestica*) in veränderten Lebensbedingungen. *In* Allg. Ztschr. Ent., Bd. 8, p. 265–267.

Griffith, A.
1908. Life history of house flies. *In* Public Health, London, v. 21, p. 122–127.

Hewitt, C. G.
1910. The house fly. 195 p., 22 pl. The University Press, Manchester, England.

Howard, L. O.
1911. The house fly, disease carrier. 312 p., 39 fig. Stokes and Co., New York.

Peairs, L. M.
1914. The relation of temperature to insect development. *In* Jour. Econ. Ent., v. 7, No. 2, p. 174–179.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO HOUSE FLIES AND OTHER HOUSEHOLD INSECTS.

AVAILABLE FOR FREE DISTRIBUTION.

Migratory Habit of House-fly Larvæ as Indicating a Favorable Remedial Measure. (Department Bulletin 14.)
A Maggot Trap in Practical Use: An Experiment in House-fly Control. (Department Bulletin 200.)
Remedies and Preventives against Mosquitoes. (Farmers' Bulletin 444.)
Stable Fly. (Farmers' Bulletin 540.)
House Flies. (Farmers' Bulletin 679.)
Bedbugs. (Entomology Circular 47.)
American Black Flies. (Entomology Technical Bulletin 26.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS.

Experiments in Destruction of Fly Larvæ in Horse Manure. (Department Bulletin 118.) Price, 10 cents.
House Flies. (Farmers' Bulletin 459.) Price, 5 cents.
Principal Household Insects of United States, with Chapter on Insects Affecting Dry Vegetable Foods. (Entomology Bulletin, n. s., 4.) Price, 10 cents.
Notes on Mosquitoes of United States, Giving Some Account of their Structure and Biology, with Remarks on Remedies. (Entomology Bulletin, n. s., 25.) Price, 10 cents.
Economic Loss to People of United States through Insects that Carry Disease. (Entomology Bulletin, n. s., 78.) Price, 10 cents.
Preventive and Remedial Work against Mosquitoes. (Entomology Bulletin, n. s., 88.) Price, 15 cents.
Habits and Life Histories of Some Flies of Family Tabanidæ. (Entomology Technical Bulletin 12, pt. 2.) Price, 10 cents.
House Ants. (Entomology Circular 34.) Price, 5 cents.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY

△

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916